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THE CAPTURE AND IMMOBILIZATION
OF THE EUROPEAN BADGER,
MELES MELES (L.), IN ITS NATURAL ENVIRONMENT

(*Mammalia*)

Abstract. — Badgers were captured in the Maremma Natural Park, central Italy, using two types of collapsible cage trap differing in the gate system. One had a vertical gate whereas the other a horizontal gate. The overall trapping success was low (2.4%) and did not differ between the two types of trap ($P > 0.50$), nor between seasons ($P > 0.90$). Badgers were immobilized by intramuscular injection of ketamine hydrochloride at a dosage of 10-15 mg/kg. Immobilization occurred after 2-4 min and lasted approximately 30 min, long enough to mark, measure and equip badgers with radio-collars. The application of this technique of capture and immobilization to other small to medium sized carnivores is suggested.

Key words: capture, European Badger, immobilization, Italy, ketamine hydrochloride, *Meles meles*.

Riassunto. — *La cattura ed immobilizzazione del Tasso europeo, Meles meles (L.), nel suo ambiente naturale.*

Viene descritta la tecnica di cattura ed immobilizzazione del Tasso europeo impiegata nell'ambito di uno studio sull'ecologia comportamentale della specie nel Parco Naturale della Maremma. Tra Settembre 1983 e Novembre 1985 sono state operate 49 catture utilizzando le trappole in 2020 occasioni (successo di cattura 2.4%). Due tipi di trappola a cassetta con un diverso sistema di chiusura sono stati usati. Il primo aveva la porta che scendeva verticalmente mentre nel secondo la porta si chiudeva obliquamente dall'interno della trappola. Il successo di cattura dei due tipi di trappola non era significativamente diverso, in ogni caso minore di 10% in ciascun mese dell'anno, e non era correlato ad alcuna variabile atmosferica. L'elenco delle altre specie catturate comprendeva istrice, cinghiale, daino, volpe e gatto. Viene sug-

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gerito l'impiego di trappole a cassetta con sistema di chiusura verticale, previa riduzione delle loro dimensioni a $40 \times 40 \times 80$ cm, onde limitarne l'uso da parte di specie di maggiore taglia (e.g. cinghiale e daino).

L'immobilizzazione è stata condotta iniettando della ketamina cloridrato nella coscia mediante cerbottana e dardo (siringa di 3-ml). Il dosaggio usato (10-15 mg/kg) permetteva di maneggiare il tasso 2-4 min dopo l'iniezione e garantiva la sua immobilizzazione per circa 30 min, un periodo di tempo sufficiente per la raccolta dei dati biometrici e la marcatura dell'animale. Nessun individuo è morto nel corso delle immobilizzazioni e nessun effetto collaterale è stato osservato in individui successivamente ricatturati.

Questo studio conferma la validità della tecnica di cattura del tasso mediante trappola a cassetta ed immobilizzazione con ketamina cloridrato. Viene infine suggerito l'uso di queste tecniche per la cattura ed immobilizzazione di altri carnivori.

1. Introduction.

Handling carnivores for research purposes such as collecting blood samples, measuring, sexing, aging, marking and fitting them with radio-collars, requires the intramuscular administration of an immobilizing agent to reduce the potential for injury to the researcher as well as to the animal (SEAL & al., 1970; HARTHOORN, 1976). Similarly, a safe and easily administered immobilizing agent, suitable for field use, may also facilitate efforts to translocate live carnivores in new surroundings (HARTHOORN, 1976). However, the live-capture and pharmacological immobilization of carnivores may be difficult because of side-effects (e.g. excitement, respiratory depression, regurgitation, body temperature changes, cf. HARTHOORN, 1965, 1976, 1977; GENEVOIS & al., 1981) that are often associated with these procedures. Although the number of studies involving the handling of carnivores in Italy has significantly increased in recent years (e.g. MACDONALD & al., 1980; BOITANI, 1984; BOITANI & al., 1984; FRANCISCI & al., 1985; BINDI & al., 1986), there is little quantitative information regarding their live-capture and immobilization in their natural environment.

The objective of this paper is to describe a safe technique for the live-capture and immobilization of the European badger (*Meles meles* L.), which has been successfully used in a study carried out in the Maremma Natural Park, central Italy (PIGOZZI, 1985 a, b, 1986, 1987 b, in press).

2. Materials and methods.

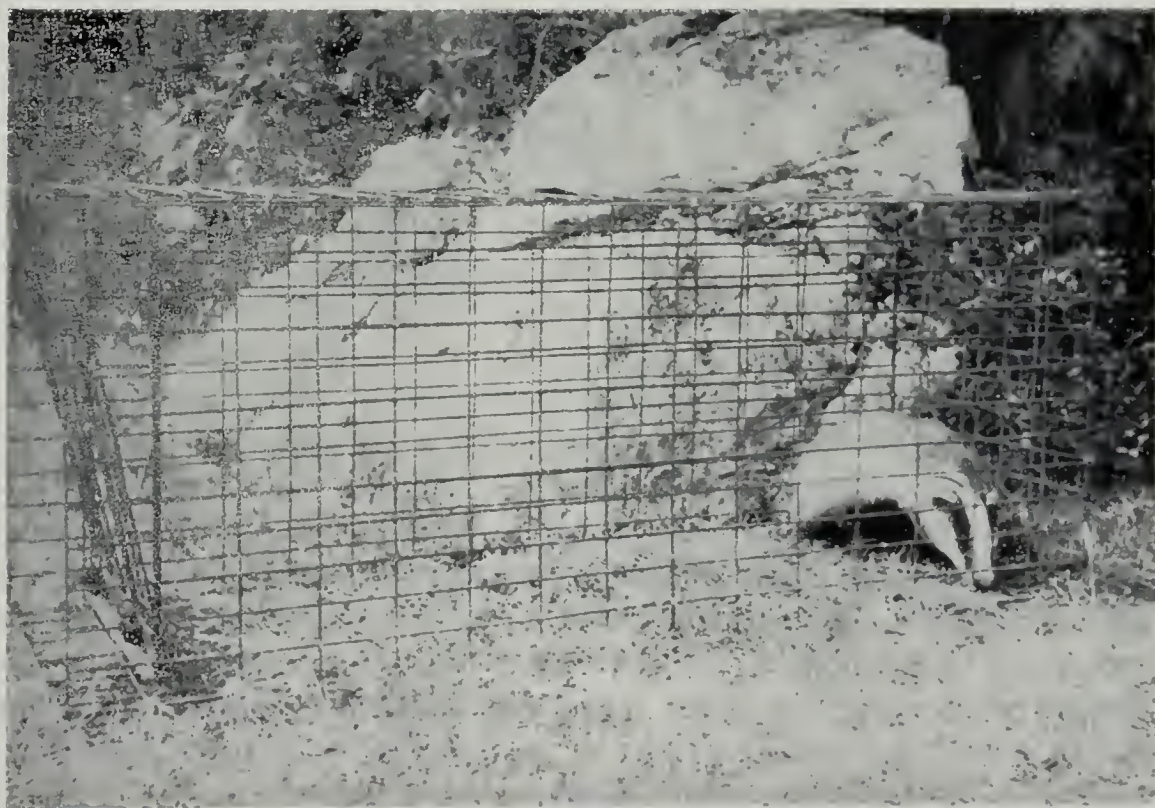
2.1. Capture.

Badgers were captured in large cage traps ($N = 13$) of welded steel mesh (5×10 cm) with a single gate and a monofilament nylon string as trigger mechanism (CHEESEMAN & MALLINSON, 1980; PARISH & KRUUK,

1982). Two types of collapsible cage traps, differing in their length and gate system, were assembled using a copper wire, (diameter of 1.5 mm). One ($50 \times 60 \times 120$ cm) (hereafter referred to as vertical gate trap ($N=5$)) had the gate, cut from 3 mm thick steel sheet, which dropped vertically (Fig. 1). The base of the gate was covered with a thick rubber layer to protect the back of the animals from possible injuries. The guides for the gate (50×120 cm) were cut from 1.5 cm wide U-shaped piece of metal. The other type ($50 \times 60 \times 150$ cm) (hereafter referred to as horizontal gate trap ($N=8$)) had the gate made of welded steel mesh (5×10 cm) which was parallel to the top of the cage when the trap was set (Fig. 2). Two spring-locking catches welded to the base of the gate blocked the door against a steel bar which was placed 10 cm inside the trap. The longer size of this cage trap was due to the extra space required by the gate to drop without hitting the animal. In both types of trap the nylon string was attached at a height of 10 cm above ground surface and at a distance of 30 cm from the bottom of the trap. When the nylon string was disturbed by the animal eating the bait, a pin was pulled allowing the gate to drop. Several baits, including maize, fish and pork meat, apples, pears, were tried but peanuts appeared to be the most effective and was used throughout the study. The bait was distributed around the trap but was more abundant near the nylon string.

Before being used, all traps were inspected for burrs and sharp edges. Traps were always set by the author to avoid variation in proficiency (cf. SNEAD, 1950) and were deployed near badger's latrines (*sensu* KRUK, 1978), setts and paths, taking care to locate them near bushes or within undergrowth when possible. They were checked daily, usually in the early morning. If the trap was empty, the trigger mechanism was examined and signs of visits or disturbance were recorded. An attempt was made to identify and record all species that visited each trap.

Most assessments of trap effectiveness are often made by comparing captures per trap-night. Yet several climatological and environmental site-dependent variables may affect trap responses of target species (e.g. CHAPMAN & TRETHEWEY, 1972; PERRY & al., 1977). Thus, for this comparison to be valid, the traps must be deployed so as to provide them with a similar probability of being visited by the target species. Accordingly, each month vertical and horizontal gate traps were alternately deployed at each location. In addition, traps were moved at regular intervals, usually less than 3 months. All traps not set on a particular week were locked open. Trapping periods usually lasted a week (a trap-week consisting of 7 trap-nights) and were repeated each month between September 1983 and November 1985.



Figs. 1-2. — Type of traps deployed during this study: vertical gate trap (above) and horizontal gate trap (below).

The trapping results (i.e. the number of captures divided by the number of operable traps per week) served as a measure of trap success. Each night that each trap was deployed counted as 1 trap-night.

Mean weekly temperature, barometric pressure and rainfall were derived from data collected by the weather station at the Impianto Depurazione Liquami of Grosseto, approximately 10 km north of the study area.

2.2. *Immobilization.*

Captured badgers were immobilized with ketamine hydrochloride (Ketalar, Parke-Davis, Casatenovo, Italy) (HUNT 1976, MACKINTOSH & al., 1976) which is a nonbarbiturate, phencyclidine-derived anaesthetic agent, previously used for restraint and surgical anaesthesia in more than 170 vertebrate species (BECK, 1976). The main advantages of this drug are its administration by intramuscular (IM) injection, the rapid and non-cumulative effect, and the wide margin of safety (RAMSDEN & al., 1976). Ketamine hydrochloride induces a state of unconsciousness in which the animal appears dissociated from its surroundings (BECK, 1976) but responds to noxious stimuli and maintains palpebral, pharyngeal, laryngeal and pedal reflexes (BECK, 1976; RAMSDEN & al., 1976). Side effects include poor muscle relaxation, convulsions, excessive salivation and excitement during recovery (e.g. GREGG & OLSEN, 1975; RAMSDEN & al., 1976).

The drug was administered by intramuscular injection in the thigh with a blow-pipe and darts (Mini-ject, Dist-Inject, Basel, Switzerland) (for more information on the preparation of darts from conventional disposable syringes see DE VOS, 1979). A 3-ml syringe and 4-cm long stainless-steel needles was used for drug delivery. Additional injections were hand delivered using a 3-ml conventional disposable syringe. Body weight was only visually estimated prior to injection, which resulted in a variation in the dosage administered. Badgers were considered tractable when they had lost all muscle control of the head and legs. Immobilized badgers were weighed, their standard measurements taken, sex and age determined. They were then fitted with radio-transmitter collars (Custom Electronics, Urbana, U.S.A.), and both ears were marked with coloured plastic tags numbered serially (Rototag, Dalton Supplies, Nettlebed-on-Thames, England). Badgers were inspected for injuries and general condition, and an antibiotic (Trofodermin, Farmitalia, Milano, Italy, or Streptosil, De Angeli, Milano, Italy) was applied topically to needle wounds, lacerations and abrasions to enhance the chance of survival of the animal (HARTHOORN, 1965). During these procedures the animals' eyes were covered with soft bandages to minimize disturbance and to protect against corneal drying, retinal damage and insect bites. Badgers

were attended until they regained muscle control and were then released under dense vegetation cover near the capture sites.

Induction time was defined as the period from injection with ketamine hydrochloride until the badger was motionless and did not respond to tactile stimuli. Immobilization time was defined as the period from complete collapse of the animal until it regained muscle control and could not be handled safely (PIGOZZI, 1987 a).

2.3. *Statistical analysis.*

The statistical tests used included standard non-parametric techniques (SIEGEL, 1956). Specific tests are identified parenthetically. Statistical significance was accepted at the 0.05 probability level and all tests were two-tailed unless otherwise stated.

3. Results.

3.1. *Capture.*

A total of 49 badger captures out of 2020 trap-nights was made throughout the study. There was no significant difference in the trapping success of vertical gate traps (21 captures out of 784 trap-nights) and horizontal gate traps (28 captures out of 1236 trap-nights) (Chi-square test with correction of continuity $\chi^2_c = 0.19$ $P > 0.50$). Accordingly, captures were pooled in the subsequent analyses irrespective of the type of trap deployed. In addition, trapping success was not significantly different between 1984 and 1985 (Wilcoxon paired-sample rank test $T = 34$ $P > 0.50$). In view of the absence of a statistical significant difference between years, data were combined to analyse seasonal changes in the trapping success. The combined data showed no significant changes in the trapping success of badgers in different seasons (Chi-square test $\chi^2 = 0.37$ d.f. = 3 $P > 0.90$). There is some suggestion of a slightly higher number of captures around the main mating period (February-April) (Fig. 3) but statistical analysis showed no significant seasonal variation (Chi-square test with correction of continuity $\chi^2_c = 2.18$ $P > 0.10$). Finally, no correlation was found between trapping success and temperature (Kendall correlation coefficient, $\tau = 0.17$ $z = 1.26$ $P > 0.10$), rainfall ($\tau = -0.04$ $z = 0.29$ $P > 0.30$) or barometric pressure ($\tau = 0.06$ $z = 0.47$ $P > 0.30$).

The list of non-target species captured during this study is shown in Table I. Several specimens of crested porcupine (*Hystrix cristata*) were often captured in both types of trap. Conversely, adult, subadult

and young wild boar (*Sus scrofa*), subadult and young fallow deer (*Dama dama*), feral cat (*Felis catus*) and young fox (*Vulpes vulpes*) were trapped exclusively in horizontal gate traps (Table I).

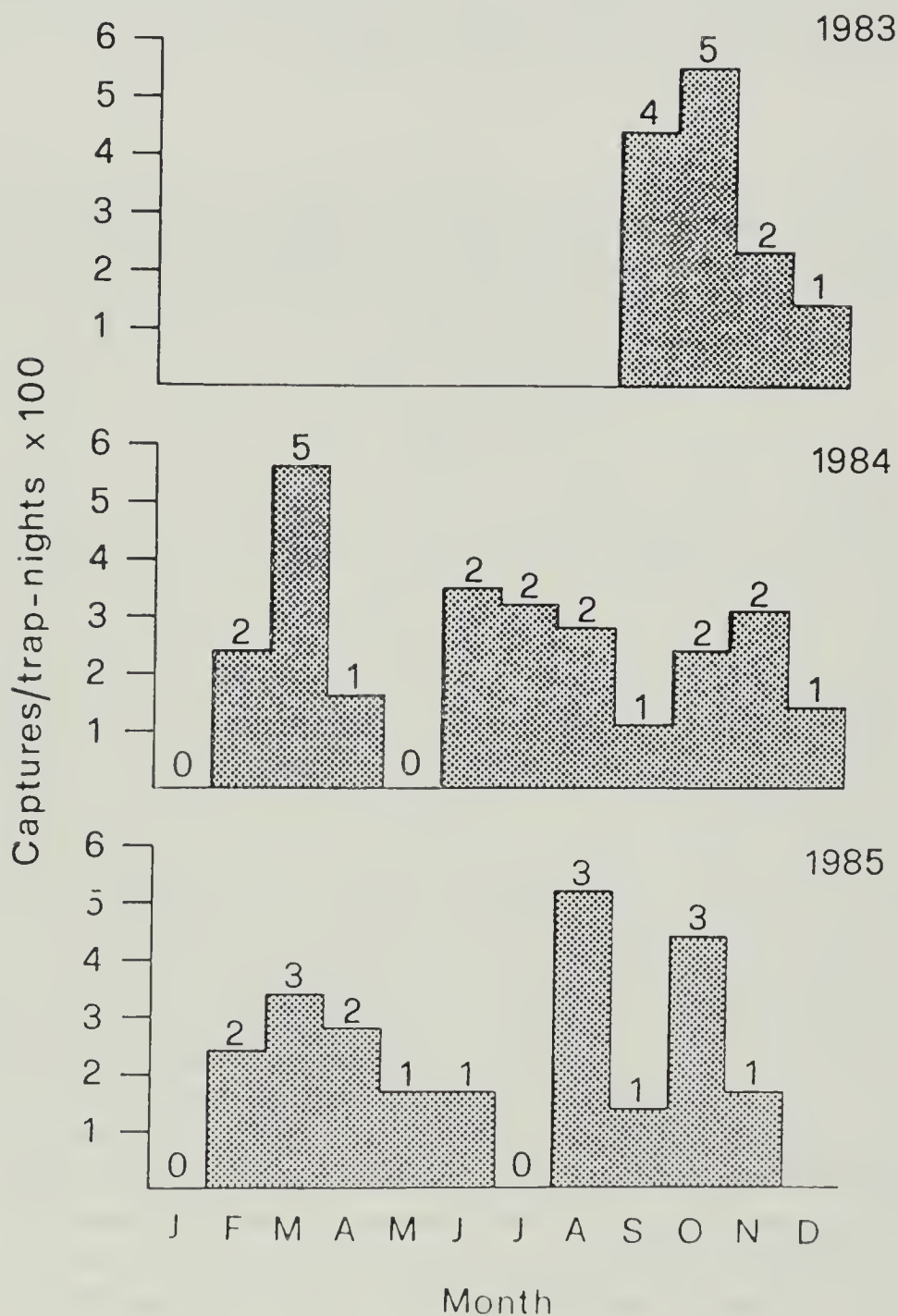


Fig. 3. — Badger captures per trap-night in different months between September 1983 and November 1985. The numbers above the histogram bars represent the actual number of captures in each month.

TABLE I. — Number of captures of different species in horizontal and vertical gate traps in the Maremma Natural Park between September 1983 and November 1985.

	Horizontal gate trap	Vertical gate trap
Badger	28	21
Crested porcupine	25	32
Wild boar	7*	0
Fallow deer	2 ⁺	0
Red fox	4**	0
Feral cat	1	0

* 1 adult, 1 subadult and 5 young.

+ 1 subadult and 1 young.

** 4 young.

No casualties were recorded during this study as a result of the trapping procedures and only occasionally were badgers found with superficial abrasions in the area above the nose, presumably caused in their attempts to escape through the meshes. On the other hand, two very thin young wild boar were found dead in the trap during the summer period, but subsequent analyses did not show any serious trap-related injury, thus suggesting that starvation was the primary cause of their deaths.

3.2. *Immobilization.*

Data on drug dosage, induction time and immobilization time were collected for 2 females and 5 males which were immobilized on 33 occasions (Table II). The small sample size of badgers immobilized during this study prevented any meaningful statistical analyses of differences in dosage levels and drug responses between sexes. Males and females received comparable dosages of ketamine hydrochloride and there was no apparent variation in the induction time and immobilization time due to sex or age differences (Table II). Induction time ranged from 2 to 7 min whereas immobilization time ranged from 16 to 63 min (Fig. 4). The first apparent effect of ketamine hydrochloride on badgers was a brief excitation period, followed by a loss of aggression and weaving of the

head from side to side. After recovering from the immobilization badgers were responsive to stimulation and appeared to behave normally.

TABLE II. — Induction and immobilization times ($\bar{X} \pm SD$) of badger immobilized by intramuscular injection of ketamine hydrochloryde (KHC).

Badger N°	Age	Sex	N° times tested	KHC dosage (mg/kg) ($\bar{X} \pm SD$)	Induction (a) time (min) ($\bar{X} \pm SD$)	Immobilization (b) time (min) ($\bar{X} \pm SD$)
C2	A	F	5	14.8 \pm 2.84	3.6 \pm 1.67	37.8 \pm 12.09
B3	A	F	13	13.0 \pm 2.92	3.7 \pm 1.70	30.8 \pm 5.97
M4	S	M	1	17.8	3.0	25.0
N5	A	M	8	13.2 \pm 4.08	3.0 \pm 1.07	36.1 \pm 12.65
O7	A	M	2	11.4 \pm 0.07	2.0 \pm 0.00	27.0 \pm 1.41
P8	Y	M	2	15.5 \pm 5.16	3.0 \pm 0.00	18.5 \pm 3.53
R9	Y	M	2	16.8 \pm 5.66	2.5 \pm 0.71	29.0 \pm 8.48

(a) period from injection with ketamine hydrochloride until the badger was motionless and did not respond to tactile stimuli.

(b) period from complete collapse of the badger until it regained muscle control and could not be handled safely.

A = Adult, S = Subadult, Y = Young
F = Female, M = Male

4. Discussion.

4.1. Capture.

The overall trapping success (2.4%) found in this study is very low compared with that reported in previous studies which used similar trapping techniques. In the south-west of England, CHEESEMÁN & MALLISON (1980) had a trapping success of approximately 17%, increasing during the summer months to 50%. Similarly, in Scotland PARISH & KRUK (1982) reported a trapping success of approximately 20%. Both studies were carried out in habitats characterized by a moderate to high badger density population, which could reach the level of 20 individual/km² in some areas of the south west of England (CHEESEMÁN & MALLINSON 1980, CHEESEMÁN & al. 1981). Although it is likely that

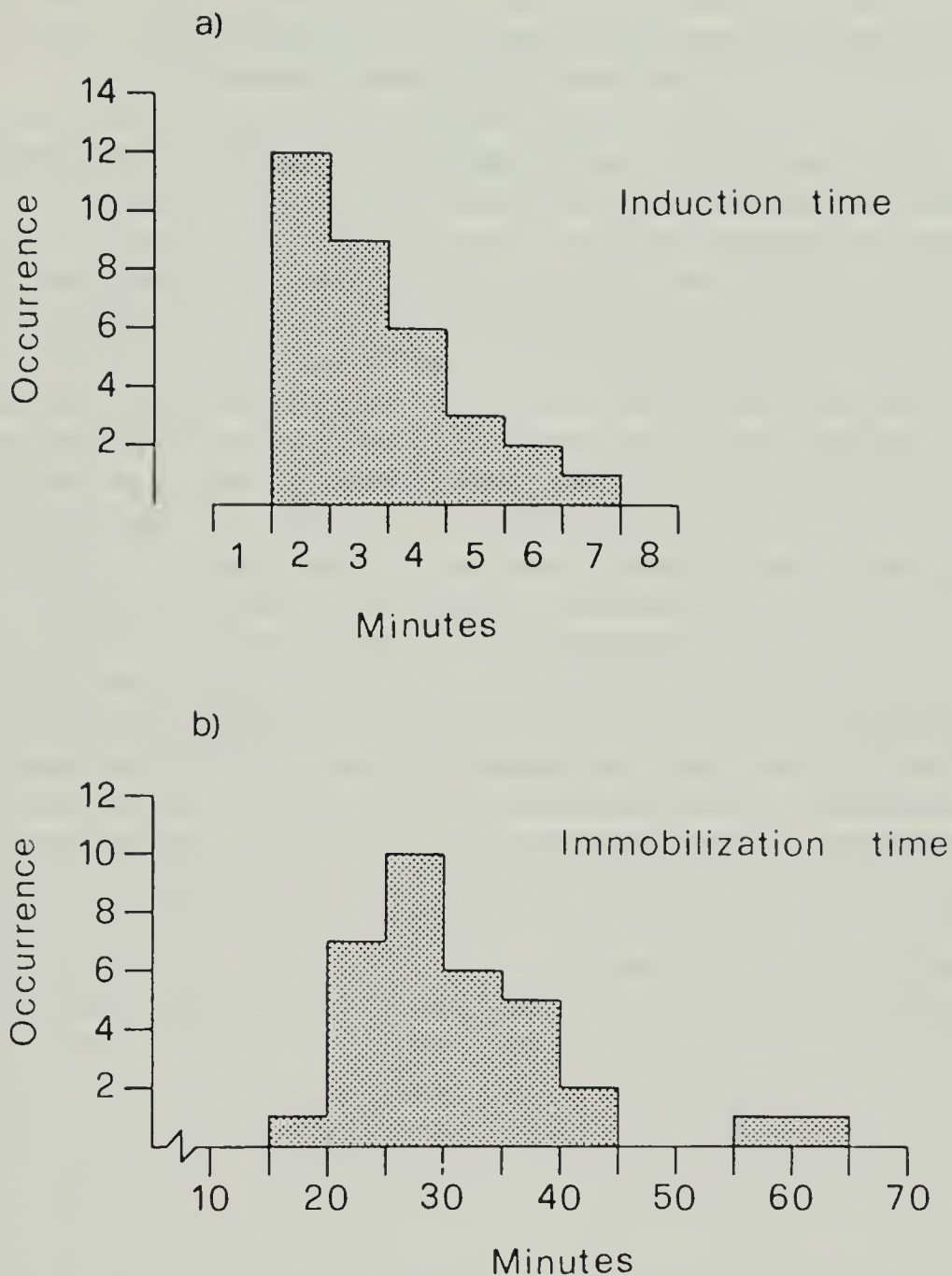


Fig. 4. — Frequency distribution of induction time (a) and immobilization time (b) for badger injected with ketamine hydrochloride.

some individuals would never be caught, one might consider the comparatively poor trapping success of this study as an indirect indicator of a low badger density in the inner part of the Maremma Natural Park.

As for the change in trapping success in different seasons, MOUCHES (1981) snared approximately 38% of a sample of badgers ($N = 34$) during

winter. This is consistent with the trapping data of the present study. However, the small number of trapped individuals ($N=7$) and the different method of capture prevent any further comparison.

Trap response of cottontail rabbit (*Sylvilagus floridanus*) was positively correlated with barometric pressure and negatively correlated with ambient temperature (HUBER 1962; CHAPMAN & TRETHEWEY 1972). However, in both studies no correlation was found between trap response and rainfall. Conversely, PERRY & al. (1977) found a negative correlation between rainfall and trap response of grey squirrel (*Sciurus carolinensis*). No apparent relationship between weather variables and trap response of badgers was found in this study. One possible reason for the lack of such correlations was that the weather variables were not measured on the actual study area. Although no specific data on wind velocity and direction were available, observations indicated that the presence of strong winds was associated with low trapping success, particularly in vertical gate traps. Subsequent controls of vertical gate traps showed that the strong winds determined a vibration of the vertical gate when the trap was set, thus producing a metallic noise which probably deterred badgers from entering the trap. In addition, the trapping results indicate that vertical gate traps were probably avoided by large mammals which are also active in daylight conditions (i.e. wild boar, fallow deer). Since the only difference between the two types of traps is related to the gate system, it seems reasonable to suggest that the shape and position of the vertical gate may deter these species from entering the trap. In fact when the vertical gate trap is set, the upper part of the gate is almost 120 cm above ground, which probably makes the trap more conspicuous to diurnal animals. Conversely, truly nocturnal species (i.e. badger, crested porcupine), which are more likely to rely on olfactory rather than visual cues, did not seem to be affected by the physical characteristics of the gate.

To reduce the likelihood of capturing wild boar and fallow deer, which caused substantial damages to the traps, I suggest the deployment of smaller size traps ($40 \times 40 \times 80$ cm) in conjunction with a vertical gate system. As for the capture of other non-target species (i.e. primarily crested porcupine, and to a lesser extent fox and feral cat), the use of baits which are less palatable to them may probably reduce the likelihood of these species visiting the traps.

4.2. Immobilization.

CHEESEMAN & MALLISON (1980) carried out 194 immobilizations of badger and found that a mean dosage of about 30 mg/kg of ketamine hydrochloride produced a mean induction time (i.e. mean time to full

relaxation) of about 2 min with a mean immobilization time (i.e. mean time to full recovery) of 44 min. HUNT (1976) injected ketamine hydrochloride to an old emaciated badger at a dosage of 26 mg/kg and, a few weeks later, of 14 mg/kg. Induction time was 6 and 10 min, whereas immobilization time was 85 and 30 min, respectively. MACKINTOSH & al. (1976) delivered ketamine hydrochloride to badgers on 57 occasions at a dosage comprised between 9.5 and 31 mg/kg. Induction time ranged from 2 to 7 min, while immobilization time ranged from 46 to 120 min, with a complete recovery in 90-180 min. Yet at a dosage of 10-15 mg/kg immobilization time was reduced to 25-30 min.

Results of this study confirm that a dosage of 10-15 mg/kg of ketamine hydrochloride produces an induction time of 2-4 min and an immobilization time of about 30 min. Induction times proved relatively constant among all individuals whereas individual differences were found in the immobilization times. For example, male P8 and R9 had immobilization times of 21 and 35 min despite similar weight and dosages of ketamine hydrochloride. Furthermore, when the same individual was recaptured, immobilization times sometimes were significantly different between each other. For example, female C2 had immobilization times of 29 and 58 min despite similar drug dosages. Likewise, male N5 had immobilization times of 23 and 42 min despite similar drug dosages. Observed variations in induction and immobilization times may result from several factors. Variations in reactions to drug may be related to age or individual differences in sensitivity (e.g. HARTHOORN, 1965; MORE, 1977; ADDISON & KOLENOSKY, 1979; BABER & COBLENTZ, 1982). Furthermore, the general physiological conditions of captured animals, ambient temperature, as well as the amount of time spent in the trap before immobilization could affect induction and immobilization times in individual animals (FITZGERALD, 1973; PIGOZZI, 1987 a). Finally, the degree of excitement of the trapped animal and the location of the administration may influence the absorption rate of drugs (HARTHOORN, 1965, 1976; MACKINTOSH & al., 1976; ADDISON & KOLENOSKY, 1979).

Ketamine hydrochloride appeared to have a wide margin of safety. On a preliminary trial a badger, not included in Table II, received a dosage of 48 mg/kg and, after a prolonged immobilization time (87 min), made an uneventful recovery. No deaths occurred as a result of administering ketamine hydrochloride and individuals recaptured and immobilized on as many as 13 occasions spanning a 2-year period showed no apparent ill effects. Similarly, no drug adaptation was experienced by individuals dosed on several occasions, nor any vomiting was recorded. Only occasionally was poor muscle relaxation and moderate salivation recorded during this study. Finally, no badger showed any sign of the disorientation expe-

rienced sometimes by crested porcupine (*Hystrix cristata*) recovering from an injection with ketamine hydrochloride (PIGOZZI, 1987 a). Unlike the American badger (*Taxidea taxus*) (FITZGERALD, 1973) and other species (cf. SEAL & ERICKSON, 1969), during the recovery period no badger tended to bang its head violently against the sides and bottom of the trap, thus inflicting minor injuries to itself.

A problem encountered in the immobilization of the American (FITZGERALD, 1973) as well as the European badger (this study) is the difficulty in the estimate of their weight before administering the drugs, which is partly due to the defensive postures assumed by most individuals and to their loose skin. To avoid the exact calculation of dosage based on weight and to expedite the administration of the drug in the field, an initial standard dose of 100 mg of ketamine hydrochloride to all age-classes except young is suggested. Supplementary doses may be given as required to maintain immobilization. For young an initial dose of 50 mg per individual is suggested.

5. Conclusions.

Wild animal capture and immobilization is far from easy (HARTHOORN, 1977). In both techniques there is no substitute for knowledge and experience. Small factors such as the location of the traps, type and amount of baits to be used, reduction of the degree of contamination of trap by human scent, assessment of the reactions of the trapped animals and timing of injection, may mean the difference between success and failure. Unfortunately, these factors are rarely described as they are experienced by field biologists (HARTHOORN, 1977). Despite all these inherent problems, the capture of the European badger by cage trap and its subsequent immobilization by intramuscular injection with ketamine hydrochloride has proven a safe and efficient technique. On the basis of the results of the present study, I suggest the use of cage traps (of the appropriate dimension and mesh size) and ketamine hydrochloride to capture and immobilize other small to medium sized carnivores.

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